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(54) **FULL BRIDGE SWITCHING CIRCUIT**

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(57) **ABSTRACT**

A full bridge switching circuit includes a converter circuit including first and second converters. The first converter includes a first transformer and a first switching element part to control the first transformer in response to a first switching signal. The second converter includes a second transformer and a second switching element part to control the second transformer in response to a second switching signal. The first and second transformers are controlled by the first and second switching element parts to output first and second feedback signals, respectively. The full bridge switching circuit further includes a third switching element part having a third switching input connected to the first and second transformers, and an IC circuit to generate an OR signal by an OR operation of a first control signal generated from the first feedback signal and a second control signal generated from the second feedback signal.

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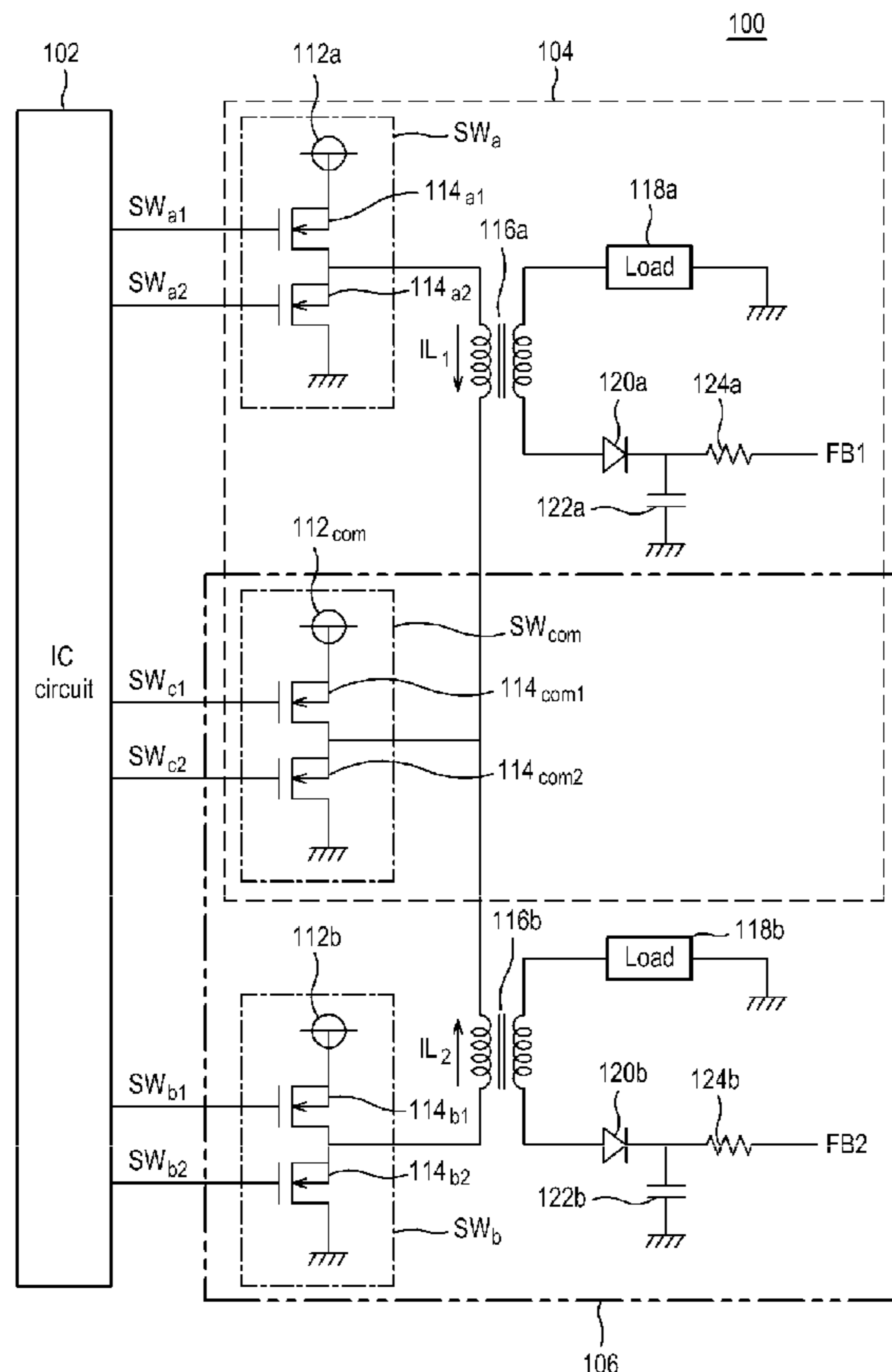


FIG. 1

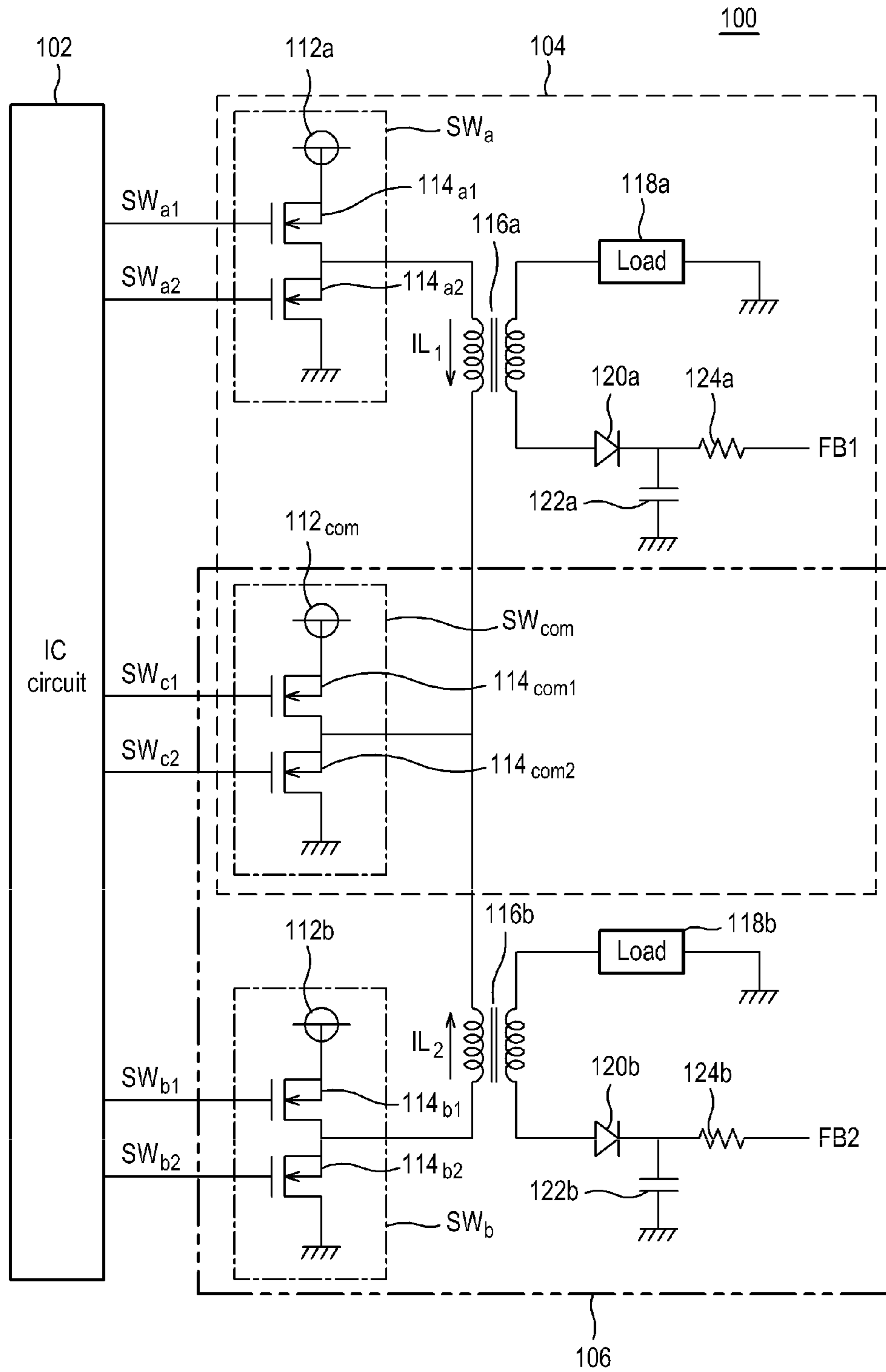


FIG. 2

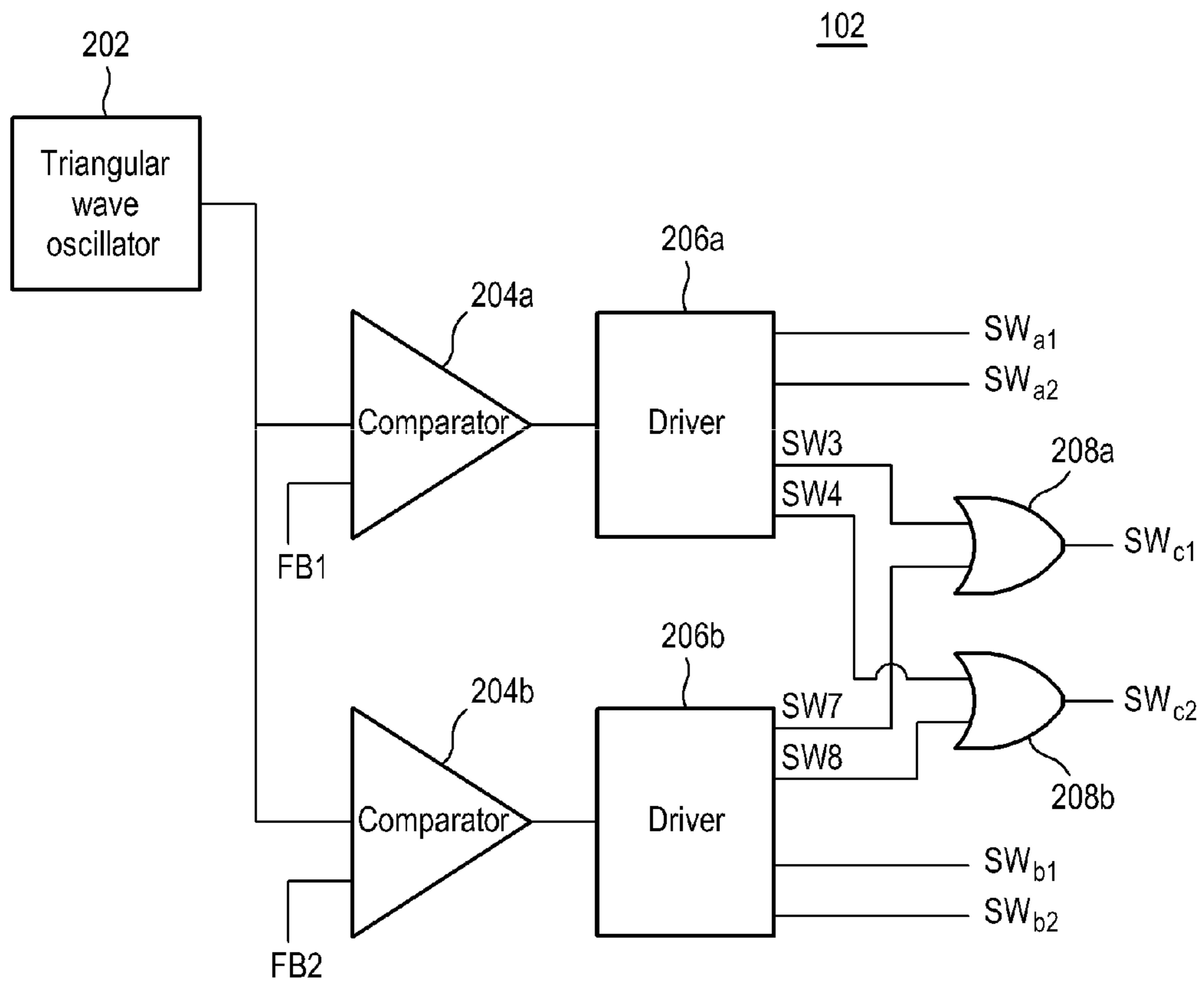
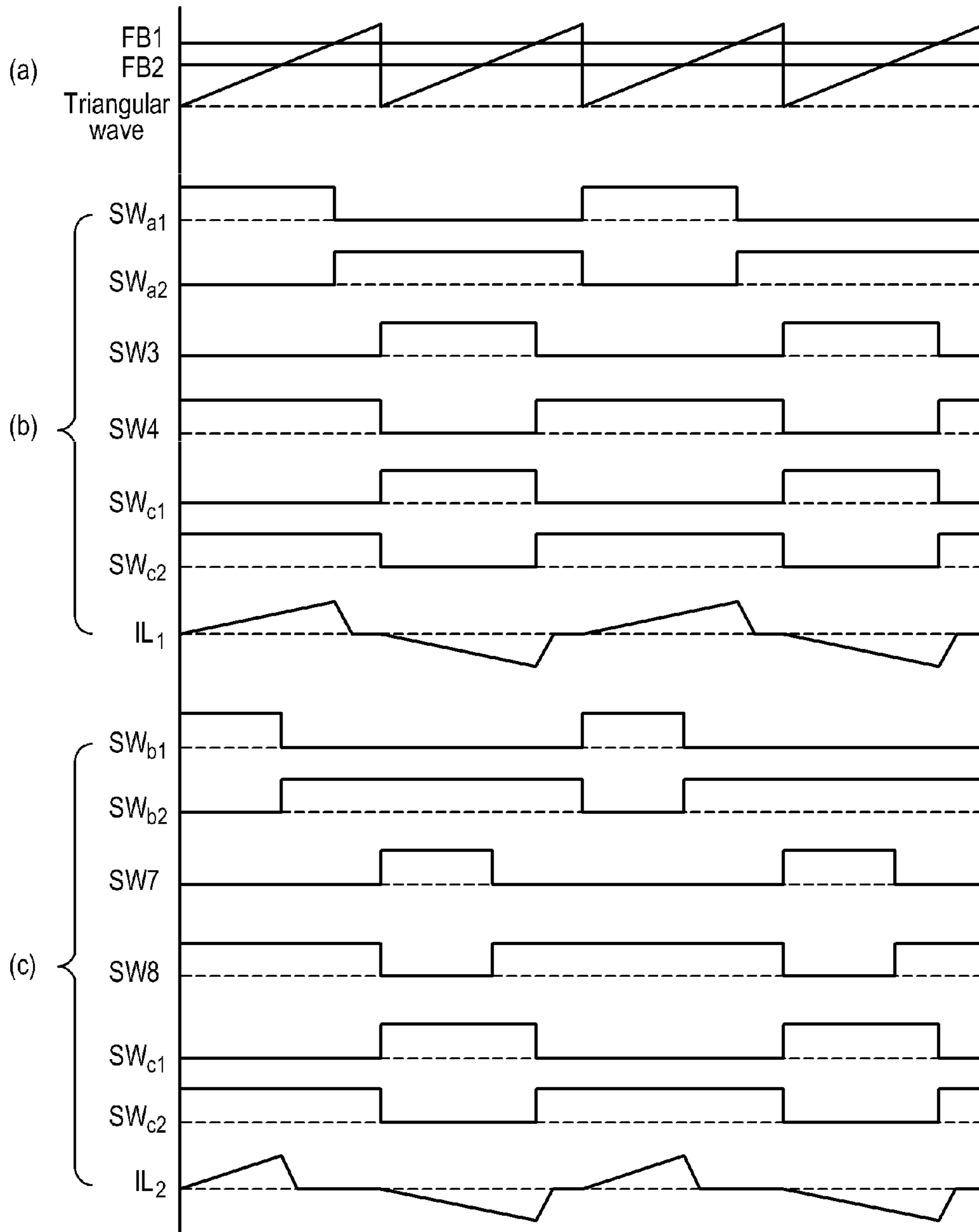


FIG. 3



FULL BRIDGE SWITCHING CIRCUIT

TECHNICAL FIELD

The present disclosure relates generally to a full bridge switching circuit and, more particularly, to a two-channel full bridge switching circuit having 6 switching elements.

BACKGROUND

An electronic device such as a power supply or an inverter to output high electric power typically includes a converter circuit which according to a control signal of a PWM circuit, amplifies the electric power to be delivered to a load. In general, such a converter circuit includes a switching circuit which converts a DC voltage signal into an AC voltage signal under control of the PWM signal. An example of the switching circuit which converts a DC voltage signal into an AC voltage signal may include a half-bridge switching circuit, a full-bridge switching circuit and a push-pull switching circuit. Among these, the full-bridge switching circuit which includes a monopolar power source and four switching elements is a switching circuit which is used for large output capacities and high output voltages.

A single channel full-bridge switching circuit having a single channel is sometimes called a "H-bridge" since a total of 4 switching elements are arranged in the form of an H with a primary coil of a transformer interposed therebetween. Typically, the full-bridge switching circuit controls the output voltage by changing the ON pulse width of each switching element while alternately making the switching elements arranged in the form of an H conductive.

With the increase in size of various electronic devices, two-channel full-bridge switching circuits have been increasingly used in place of single channel full-bridge switching circuits. A conventional two-channel full-bridge switching circuit is generally constructed using two single-channel full-bridge switching circuits, including a total of 8 switching elements. Since each channel in the two-channel full-bridge switching circuit needs to be separately controlled, an integrated circuit (IC) has to control operation of the respective 8 switching elements. However, since such two-channel full-bridge switching circuits have many switching elements, the configuration is complicated which increases the cost and size of the circuit.

Relating to the above problem, in an effort to reduce the number of switching elements, a two-channel full-bridge switching circuit having 6 switching elements has been developed. Such a switching circuit is configured to short-circuit one terminal of each primary coil of the transformers for two channels to form a common node, and use two switching elements connected to the common node commonly for both channels. The switching circuit having such configuration has to control the channels separately and, therefore, employs a phase-shift method to obtain a desired result by controlling the ON/OFF time of the remaining switching elements for circuit operation based on the ON/OFF time of a switching element connected to the common node and a corresponding potential of the common node.

Therefore, there is a need for a two-channel full-bridge switching circuit having 6 switching elements, which is capable of controlling channels separately without using a complicated phase-shift method for control.

SUMMARY

The present disclosure provides some embodiments of a two-channel full-bridge switching circuit having 6 switching

elements, which is capable of controlling channels separately without using a complicated phase-shift method for control.

According to one embodiment of the present disclosure, a full bridge switching circuit is provided. The full bridge switching circuit includes a converter circuit including a first converter and a second converter. The first converter includes a first transformer and a first switching element part to control the first transformer in response to a first switching signal, the second converter includes a second transformer and a second switching element part to control the second transformer in response to a second switching signal, and the first and second transformers are controlled by the first and second switching element parts to output first and second feedback signals, respectively. The full bridge switching circuit further includes a third switching element part which has a third switching input. The third switching element part is connected to the first and second transformers. An IC circuit is configured to generate an OR signal which results from an OR operation of a first control signal generated based on the first feedback signal and a second control signal generated based on the second feedback signal. The OR signal is fed back to the third switching input.

According to an alternate embodiment of the present disclosure, the third switching element part may further control the first and second transformers in response to the OR signal.

According to another alternate embodiment of the present disclosure, the third switching element part may further include first and second switches which are interconnected, and the first and second transformers may include respective primary coils. One terminal of the primary coils may be interconnected and a contact point between the first and second switches may be connected to a contact point between the primary coils. The OR signal may control ON/OFF operations of the first and second switches and the first and second switches may control the current flow of the primary coils.

According to another embodiment of the present disclosure, the first converter may include third and fourth switches to control current flow of the primary coil of the first transformer, the second converter may include fifth and sixth switches to control current flow of the primary coil of the second transformer, and the IC circuit may generate a third control signal to control ON/OFF operations of the third and fourth switches based on the first feedback signal and generate a fourth control signal to control ON/OFF operations of the fifth and sixth switches based on the second feedback signal.

According another alternate embodiment of the present disclosure, the first and second control signals may include both a control signal for the first switch and a control signal for the second switch.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view showing a converter circuit according to one embodiment of the present disclosure.

FIG. 2 is a view showing an internal configuration of an IC circuit shown in FIG. 1.

FIG. 3 is a timing chart showing: (a) a relationship among a triangular wave oscillating signal and feedback signals FB1 and FB2; (b) a relationship among switch control signals SW_{a1} , SW_{a2} , SW3 and SW4 output from a driver 206a, switch control signals SW_{c1} and SW_{c2} output from OR gates 208a and 208b, and current IL_1 flowing into a primary coil of a transformer 116a; and (c) a relationship among switch control signals SW_{b1} , SW_{b2} , SW7 and SW8 output from a driver 206b, the switch control signals SW_{c1} and SW_{c2} output

from the OR gates **208a** and **208b**, and current IL_2 flowing into a primary coil of a transformer **116b**.

DETAILED DESCRIPTION

An embodiment of the present disclosure will now be described in detail with reference to the drawings. In the following description, a concrete description on related functions or constructions will be omitted if it is deemed that the functions and/or construction may unnecessarily obscure the gist of the present disclosure. It should be understood that the following disclosures are merely embodiments which are not to be construed to limit the scope and spirit of the invention.

FIG. 1 is a schematic view showing a converter circuit **100** according to one embodiment of the present disclosure. As shown, the converter circuit **100** includes an IC circuit **102**, a first switching element part SW_a , a second switching element part SW_{com} and a third switching element part SW_b .

The IC circuit **102** outputs 6 switch control signals SW_{a1} , SW_{a2} , SW_{c1} , SW_{c2} , SW_{b1} and SW_{b2} . These switch control signals SW_{a1} , SW_{a2} , SW_{c1} , SW_{c2} , SW_{b1} and SW_{b2} output from the IC circuit **102** are PWM control signals which may define voltages to be output to loads based on combinations of ON/OFF durations of these signals. An internal configuration of the IC circuit **102** will be described later with reference to FIG. 2.

As shown in FIG. 1, the first switching element part SW_a , the second switching element part SW_b and the third switching element part SW_b may include their respective power sources **112a**, **112com** and **112b**. These power sources **112a**, **112com** and **112b** may be DC voltage sources.

The first switching element part SW_a may include switching elements 114_{a1} and 114_{a2} . According to one embodiment of the present disclosure, the switching elements 114_{a1} and 114_{a2} may be MOSFET switches without being limited thereto. As shown, a source terminal of the switching element 114_{a1} is connected to the power source **112a** and the switch control signal SW_{a1} input from the IC circuit **102** may be applied to a gate terminal of the switching element 114_{a1} . A drain terminal of the switching element 114_{a1} may be connected to a source terminal of the switching element 114_{a2} . A drain terminal of the switching element 114_{a2} may be grounded.

The second switch element part SW_{com} may include switching elements 114_{com1} and 114_{com2} . According to one embodiment of the present disclosure, the switching elements 114_{com1} and 114_{com2} may be MOSFET switches without being limited thereto. As shown, a source terminal of the switching element 114_{com1} is connected to the power source **112com** and the switch control signal SW_{c1} input from the IC circuit **102** may be applied to a gate terminal of the switching element 114_{com1} . A drain terminal of the switching element 114_{com1} may be connected to a source terminal of the switching element 114_{com2} . A drain terminal of the switching element 114_{com2} may be grounded.

The third switching element part SW_b may include switching elements 114_{b1} and 114_{b2} . According to one embodiment of the present disclosure, the switching elements 114_{b1} and 114_{b2} may be MOSFET switches without being limited thereto. As shown, a source terminal of the switching element 114_{b1} is connected to the power source **112b** and the switch control signal SW_{b1} input from the IC circuit **102** may be applied to a gate terminal of the switching element 114_{b1} . A drain terminal of the switching element 114_{b1} may be connected to a source terminal of the switching element 114_{b2} . A drain terminal of the switching element 114_{b2} may be grounded.

As shown, the converter circuit **100** may also include a transformer **116a**. A start terminal of a primary coil of the transformer **116a** is connected to a contact point between the switch elements 114_{a1} and 114_{a2} and a finish terminal of the primary coil of the transformer **116a** is connected to a contact point between the switch elements 114_{com1} and 114_{com2} . DC voltage signals applied from the power sources **112a** and **112com** may be converted into AC voltage signals according to ON/OFF control of the elements 114_{a1} and 114_{a2} and the switch elements 114_{com1} and 114_{com2} and then applied to the primary coil of the transformer **116a**. The AC voltage signals applied to the primary coil of the transformer **116a** may induce a predetermined voltage signal in a secondary coil of the transformer **116a** and accordingly the induced voltage signal may be applied to a load **118a** having one terminal connected to the secondary coil. The other terminal of the load **118a** may be grounded.

As shown, the converter circuit **100** may also include a transformer **116b**. A start terminal of a primary coil of the transformer **116b** is connected to a contact point between the switch elements 114_{b1} and 114_{b2} and a finish terminal of the primary coil of the transformer **116b** is connected to the contact point between the switch elements 114_{com1} and 114_{com2} . DC voltage signals applied from the power sources **112com** and **112b** may be converted into AC voltage signals according to ON/OFF control of the elements 114_{b1} and 114_{b2} and the switch elements 114_{com1} and 114_{com2} and then applied to the primary coil of the transformer **116b**. The AC voltage signals applied to the primary coil of the transformer **116b** may induce a predetermined voltage signal in a secondary coil of the transformer **116b** and accordingly the induced voltage signal may be applied to a load **118b** having one terminal connected to the secondary coil. The other terminal of the load **118b** may be grounded.

As shown, the opposite terminals of the secondary coils of the transformers **116a** and **116b** may be connected to anode terminals of diodes **120a** and **120b**, respectively. The diodes **120a** and **120b** are used to obtain a DC voltage signal by removing a negative component from an AC voltage signal. Cathode terminals of the diodes **120a** and **120b** may be connected to one terminal of capacitors **122a** and **122b**, respectively. Contact points between the cathode terminals of the diodes **120a** and **120b** and the capacitors **122a** and **122b** may be connected to one terminal of resistors **124a** and **124b**, respectively. The resistors **124a** and **124b** are used to prevent an overcurrent. The other terminals of the resistors **124a** and **124b** output feedback signals FB1 and FB2, respectively, which may be fed back to the IC circuit **102** although not shown.

The first switch element part SW_a , the second switch element part SW_{com} and the transformer **116a**, shown in FIG. 1, may form a first channel of the converter circuit **100**. In addition, the second switch element part SW_{com} , the third switch element part SW_{com} and the transformer **116b** may form a second channel of the converter circuit **100**.

FIG. 2 is a view showing an internal configuration of the IC circuit **102** shown in FIG. 1.

As shown, the IC circuit **102** may include a triangular wave oscillator **202**. The triangular wave oscillator **202** may generate a triangular wave oscillating signal according to a predetermined cycle. The triangular wave oscillating signal may be a triangular wave signal having a rising edge and a falling edge which are symmetrical, or a triangular wave signal of substantially a right triangle shape having substantially a vertical falling edge.

The IC circuit **102** may further include comparators **204a** and **204b**. The comparators **204a** and **204b** may receive the

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triangular wave oscillating signal generated from the triangular wave oscillator **202**, as an input of their respective one terminal. The comparators **204a** and **204b** may receive the feedback signals **FB1** and **FB2** fed back from each channel of the converter circuit **100**, as an input of their respective other terminal. The comparators **204a** and **204b** may compare the received triangular wave oscillating signal with the received feedback signals **FB1** and **FB2** and output a result of the comparison.

The IC circuit **102** may further include drivers **206a** and **206b**. The driver **206a** may receive the comparison result from the comparator **204a** and generate ON/OFF control signals for the switch elements SW_{a1} and SW_{a2} of the converter circuit **100** based on the received comparison result. The driver **206a** may also generate two additional control signals **SW3** and **SW4** which may be used to generate ON/OFF control signals for the switch elements SW_{c1} and SW_{c2} later. Likewise, the driver **206b** may receive the comparison result from the comparator **204b** and generate ON/OFF control signals for the switch elements SW_{b1} and SW_{b2} of the converter circuit **100** based on the received comparison result. The driver **206b** may also generate two additional control signals **SW7** and **SW8** which may be used to generate ON/OFF control signals for the switch elements SW_{c1} and SW_{c2} later.

The IC circuit **102** may further include two OR gates **208a** and **208b**. The OR gate **208a** may receive the control signal **SW3** from the driver **206a** and the control signal **SW7** from the driver **206b** and output a result of the OR operation for the received control signals. The OR operation result output from the OR gate **208a** may be input as an ON/OFF control signal for the switch element SW_{c1} . The OR gate **208b** may receive the control signal **SW4** from the driver **206a** and the control signal **SW8** from the driver **206b** and output a result of the OR operation for the received control signals. The OR operation result output from the OR gate **208b** may be input as an ON/OFF control signal for the switch element SW_{c2} .

FIG. **3** is a timing chart showing respective signals flowing in the IC circuit **102** shown in FIG. **2** and a change in a phase of current flowing through each primary coil of each transformer **116a** and **116b** in the converter circuit **100**.

FIG. **3(a)** is a timing chart showing a relationship between a triangular wave oscillating signal and the feedback signals **FB1** and **FB2** fed back from the converter circuit **100** to the IC circuit **102**. As shown, the triangular wave oscillating signal is a saw-toothed signal having a vertical falling edge. As shown, the feedback signal **FB1** has a value which is slightly greater than that of the feedback signal **FB2**.

FIG. **3(b)** is a timing chart showing a relationship between the switch control signals SW_{a1} , SW_{a2} , **SW3** and **SW4** output from the driver **206a**, the switch control signals SW_{c1} and SW_{c2} output from the OR gates **208a** and **208b**, and current IL_1 flowing into the primary coil of the transformer **116a**. As shown, the switch control signal SW_{a1} and the switch control signal SW_{a2} are signals alternating between ON/OFF states with their respective cycles and have opposite phases. As shown, the switch control signal SW_{a1} has a falling edge at a point where the triangular wave signal is greater than the feedback signal **FB1**, with its OFF interval longer than its ON interval. As shown, the control signal **SW3** and the control signal **SW4** are signals alternating between ON/OFF states with their respective cycles and have opposite phases. As shown, the control signal **SW3** has a rising edge at a point where the triangular wave signal is reset, with its OFF interval longer than its ON interval. As shown, the switch control signals SW_{c1} and SW_{c2} and the control signals **SW3** and **SW4** have the same phase.

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As shown in FIG. **3(b)**, a phase of the current IL_1 flowing into the primary coil of the transformer **116a** has a smoothly-inclined rising edge when the switch control signals SW_{a1} and SW_{c2} go into an ON state and the switch control signals SW_{a2} and SW_{c1} go into an OFF state, and has a falling edge steeper than the rising edge from a point where the triangular wave signal is greater than the feedback signal **FB1**, that is, from a falling edge of the switch control signal SW_{a1} . In addition, the phase of current IL_1 flowing into the primary coil of the transformer **116a** is kept at zero up to a point where the triangular wave signal is reset, that is, up to a rising edge of the switch control signal SW_{c1} , and has a negative potential as it falls with a smooth declination from that point. Then, this phase has a steep rising edge from a point where a next triangular wave signal is greater than the feedback signal **FB1**, that is, from a falling edge of the switch control signal SW_{c2} . Then, the phase of current IL_1 flowing into the primary coil of the transformer **116a** is again kept at zero up to a point where the triangular wave signal is reset, that is, up to the rising edge of the switch control signal SW_{c1} .

FIG. **3(c)** is a timing diagram showing a relationship between the switch control signals SW_{b1} , SW_{b2} , **SW7** and **SW8** output from the driver **206b**, the switch control signals SW_{c1} and SW_{c2} output from the OR gates **208a** and **208b**, and current IL_2 flowing into the primary coil of the transformer **116b**. As shown, the switch control signal SW_{b1} and the switch control signal SW_{b2} are signals alternating between ON/OFF states with their respective cycles and have opposite phases. As shown, the switch control signal SW_{b1} has a falling edge at a point where the triangular wave signal is greater than the feedback signal **FB2**, with its OFF interval longer than its ON interval. As shown, the control signal **SW7** and the control signal **SW8** are signals alternating between ON/OFF states with their respective cycles and have opposite phases. In addition, the control signal SW_{c1} and the control signal SW_{c2} are also signals alternating between ON/OFF states with their respective cycles and have opposite phases. As shown, the control signal **SW7** has a rising edge at a point where the triangular wave signal is reset, with its OFF interval longer than its ON interval. As shown, the switch control signal SW_{c1} is equal to that shown in FIG. **3(b)** and has an ON interval longer than that of the control signal **SW7**. The switch control signal SW_{c2} is also equal to that shown in FIG. **3(b)** and has an OFF interval longer than that of the control signal **SW8**.

As shown in FIG. **3(c)**, a phase of the current IL_2 flowing into the primary coil of the transformer **116b** has a smoothly-inclined rising edge when the switch control signals SW_{b1} and SW_{c2} go into an ON state and the switch control signals SW_{b2} and SW_{c1} go into an OFF state, and has a falling edge steeper than the rising edge from a point where the triangular wave signal is greater than the feedback signal **FB2**, (i.e. from a falling edge of the switch control signal SW_{a1}). In addition, the phase of current IL_2 flowing into the primary coil of the transformer **116b** is kept at zero up to a point where the triangular wave signal is reset, that is, up to a rising edge of the switch control signal SW_{c1} , and has a negative potential as it falls with a smooth declination from that point. Then, this phase has a steep rising edge from a point where a next triangular wave signal is greater than the feedback signal **FB2**, that is, from a falling edge of the switch control signal SW_{c2} . Then, the phase of current IL_2 flowing into the primary coil of the transformer **116b** is again kept at zero up to a point where the triangular wave signal is reset, that is, up to the rising edge of the switch control signal SW_{c1} .

As shown in FIGS. **3(b)** and **(c)**, the currents flowing into the primary coils of the transformers **116a** and **116b** may be

controlled to have different phases. It is apparent to those skilled in the art that the phases of the currents flowing into these primary coils can be properly controlled to supply desired power to a load eventually.

According to the present disclosure in some embodiments, it is possible to obtain a two-channel full-bridge switching circuit with a simple structure and easy control. The two-channel full-bridge switching circuit has advantages of a reduced number of switching elements, simple structure, reduced cost and space, and convenience in use due to separate control of channels with a simple method without complicated control of a phase-shift method.

While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the disclosures. Indeed, the novel methods and apparatuses described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the disclosures. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the disclosures.

What is claimed is:

1. A full bridge switching circuit comprising:
 - a converter circuit including a first converter and a second converter, the first converter including a first transformer and a first switching element part to control the first transformer in response to a first switching signal, the second converter including a second transformer and a second switching element part to control the second transformer in response to a second switching signal, the first and second transformers being controlled by the first and second switching element parts to output first and second feedback signals under, respectively;
 - a third switching element part including a third switching signal, the third switching element part being connected to the first and second transformers; and
 - an IC circuit configured to generate an OR signal which results from an OR operation of a first control signal generated based on the first feedback signal and a second control signal generated based on the second feedback signal, the OR signal being fed back to the third switching signal,
 wherein the first and second transformers include respective secondary coils, and
 - wherein the first converter includes:
 - a first load which is connected to a first terminal of the secondary coil of the first transformer;
 - a first diode which has an anode connected to a second terminal of the secondary coil of the first transformer and a cathode for outputting a first DC voltage signal;
 - a first capacitor which is connected to the cathode of the first diode; and
 - a first resistor which has a first resistor terminal connected to the cathode of the first diode and a second resistor terminal to output the first feedback signal based on the first DC voltage signal.
2. The full bridge switching circuit of claim 1, wherein the third switching element part further controls the first and second transformers in response to the OR signal.
3. The full bridge switching circuit of claim 2, wherein the third switching element part further includes first and second switches which are interconnected, and
 - wherein the first and second transformers include respective primary coils, with one terminal of the primary coils interconnected, a contact point between the first and

second switches being connected to a contact point between the primary coils, the OR signal controls ON/OFF operations of the first and second switches, and the first and second switches control current flow of the primary coils.

4. The full bridge switching circuit of claim 3, wherein the first converter includes third and fourth switches to control first current flow of the primary coil of the first transformer and the second converter includes fifth and sixth switches to control second current flow of the primary coil of the second transformer, and

wherein the IC circuit generates third and fourth control signals to control ON/OFF operations of the third and fourth switches based on the first feedback signal and generates fifth and sixth control signal to control ON/OFF operations of the fifth and sixth switches respectively based on the second feedback signal.

5. The full bridge switching circuit of claim 4, wherein the first and second control signals include both of a control signal for the first switch and a control signal for the second switch.

6. The full bridge switching circuit of claim 4, wherein a phase of the first current flowing into the primary coil of the first transformer has a smoothly-inclined rising edge when the third control signal goes into an ON state and the fourth control signal goes into an OFF state, has a falling edge steeper than the rising edge from a falling edge of the third control signal, is kept at zero up to a rising edge of the OR signal for controlling the first switch, and has a negative potential as the phase falls with a smooth declination from the rising edge of the OR signal for controlling the first switch.

7. The full bridge switching circuit of claim 4, wherein a phase of the second current flowing into the primary coil of the second transformer has a smoothly-inclined rising edge when the fifth control signal goes into an ON state and the sixth control signal goes into an OFF state, has a falling edge steeper than the rising edge from a falling edge of the fifth control signal, is kept at zero up to a rising edge of the OR signal for controlling the first switch, and has a negative potential as the phase falls with a smooth declination from the rising edge of the OR signal for controlling the first switch.

8. The full bridge switching circuit of claim 4, wherein the IC circuit further includes: OR gates which receive signals outputted from the first and second drivers to output the OR signal.

9. The full bridge switching circuit of claim 8, wherein the signals outputted from the first and second drivers to output the OR signal have rising edges at a point where the triangular wave oscillating signal is reset, and

wherein an OFF interval of the signals is longer than an ON interval of the signal.

10. The full bridge switching circuit of claim 1, wherein the second converter includes:

- a second load which is connected to a first terminal of the secondary coil of the second transformer;
- a second diode which has an anode connected to a second terminal of the secondary coil of the second transformer and a cathode for outputting a second DC voltage signal;
- a second capacitor which is connected to the cathode of the second diode; and
- a second resistor which has a first resistor terminal connected to the cathode of the second diode and a second resistor terminal to output the second feedback signal based on the second DC voltage signal.

11. A full bridge switching circuit comprising:

- a converter circuit including a first converter and a second converter, the first converter including a first transformer

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and a first switching element part to control the first transformer in response to a first switching signal, the second converter including a second transformer and a second switching element part to control the second transformer in response to a second switching signal, the first and second transformers being controlled by the first and second switching element parts to output first and second feedback signals under, respectively;

a third switching element part including a third switching signal, the third switching element part being connected to the first and second transformers; and

an IC circuit configured to generate an OR signal which results from an OR operation of a first control signal generated based on the first feedback signal and a second control signal generated based on the second feedback signal, the OR signal being fed back to the third switching signal, wherein the IC circuit includes:

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a triangular wave oscillator which generates a triangular wave oscillating signal; a first comparator which compares the triangular wave oscillating signal with the first feedback signal to output a first comparison result;

a second comparator which compares the triangular wave oscillating signal with the second feedback signal to output a second comparison result;

a first driver which receives the first comparison result to generate the first switching signal and a first control signal;

a second driver which receives the second comparison result to generate the second switching signal and a second control signal; and

a logic circuit which receives the first control signal and the second control signal to generate the OR signal, wherein the first feedback signal has a value which is greater than that of the second feedback signal.

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